

What is claimed is:

1. An integrated process for the separation of air by cryogenic distillation and liquefaction of natural gas in which at least part of the refrigeration required to
5 liquefy the natural gas is derived from at least one cryogenic air distillation plant comprising a main heat exchanger and distillation columns, wherein the natural gas liquefies by indirect heat exchange in a heat exchanger with a cold fluid, the cold fluid being sent to the heat exchanger at least partially in liquid form and undergoing at least a partial vaporization in the heat
10 exchanger.
2. The process according to Claim 1, wherein isentropic expansion provides the refrigeration for the liquefaction of the natural gas.
- 15 3. The process according to Claim 2, wherein the air separation unit comprises a double column, with a thermally linked medium pressure column and low pressure column and wherein air is expanded in a turbine before being sent to the medium pressure column.
- 20 4. The process according to Claim 1, wherein the natural gas is liquefied within the main heat exchanger of a/the cryogenic air distillation plant, in which feed air for the cryogenic air distillation plant is cooled to a temperature suitable for distillation and the cold fluid is at least one liquid stream, enriched in at least one of oxygen, nitrogen and argon with respect to air, which vaporises in the
25 main heat exchanger.
5. The process according to Claim 4, wherein all the air to be separated in the cryogenic air distillation plant is cooled in the main heat exchanger.
- 30 6. The process according to Claim 5, wherein the natural gas is liquefied by heat exchange in an additional heat exchanger other than the main heat exchanger with at least one cold fluid which has previously been cooled by a vaporising liquid in the main heat exchanger of at least one air distillation plant.

- 5 7. The process according to Claim 6, wherein the natural gas is liquefied by means of a closed circuit in which a cold fluid flows, said cold fluid being warmed by heat exchange with the liquefying vaporising natural gas and cooled by heat exchange in the main heat exchanger.
- 10 8. The process according to Claim 6, wherein the cold fluid is chosen from the group comprising nitrogen, argon, CF₄, HCF₃, methane, ethane, ethylene and propane.
- 15 9. The process according to Claim 6, wherein gaseous nitrogen from the cryogenic air distillation plant is sent to the additional heat exchanger.
- 10 10. The process according to Claim 1, wherein the cryogenic air distillation plant produces pressurised oxygen for at least one GTL plant, a methanol plant and a DME plant fed by natural gas.
- 20 11. The process according to Claim 1, wherein all of the refrigeration required to liquefy the natural gas is derived from a single cryogenic air distillation plant, the columns of the plant, the main heat exchanger and the further heat exchanger being situated within a single cold box.
- 25 12. The process according to Claim 1, wherein part of the refrigeration required to liquefy the natural gas is derived from at least two cryogenic air distillation plants, each comprising a main heat exchanger and distillation columns, said main heat exchanger and distillation columns being within the cold box, the part of the refrigeration required to liquefy the natural gas being produced by vaporisation of at least one liquid stream, enriched in oxygen, nitrogen or argon, produced by one of the distillation columns, and the natural gas
- 30 liquefies by heat exchange in a further heat exchanger by heat exchange with a cold fluid removed from each cryogenic air distillation plant.
13. The process according to Claim 1, wherein the natural gas prior to undergoing indirect heat exchange with said cold fluid is at least partially precooled at a

temperature below 0°C by indirect heat exchange with at least one fluid not derived from any cryogenic air distillation plant.

- 5 14. The process according to Claim 13, wherein said fluid(s) not derived from any cryogenic air distillation plant comprises propane.
- 10 15. Integrated apparatus for the separation of air by cryogenic distillation and liquefaction of natural gas in which at least part of the refrigeration required to liquefy the natural gas is derived from at least one cryogenic air distillation plant comprising a main heat exchanger and distillation columns, comprising means for sending natural gas and a cold fluid at least partially in liquid form to a heat exchanger, means for removing liquefied natural gas from the heat exchanger and means for removing at least partially vaporised cold fluid from the heat exchanger.
- 15 16. The apparatus according to Claim 15, wherein isentropic expansion provides the refrigeration for the liquefaction of the natural gas.
- 20 17. The apparatus according to Claim 15 wherein the air separation unit comprises a double column, with a thermally linked medium pressure column and low pressure column and a turbine in which air is expanded and means for sending the expanded air to the medium pressure column.
- 25 18. The apparatus according to Claim 15 comprising means for sending the natural gas to be liquefied to the main heat exchanger of a/the cryogenic air distillation plant, and wherein the cold fluid is at least one liquid stream, enriched in at least one of oxygen, nitrogen and argon with respect to air, which vaporises in the main heat exchanger.
- 30 19. The apparatus according to Claim 18 comprising means for sending all the air to be separated to the main heat exchanger.
20. The apparatus according to Claim 5 comprising an additional heat exchanger other than the main heat exchanger and means for sending the natural gas to

be liquefied and at least one cold fluid which has previously been cooled by a vaporising liquid in the main heat exchanger of at least one air distillation plant to the additional heat exchanger.

- 5 21. The apparatus according to Claim 20 comprising a closed circuit passing through the main and additional heat exchangers in which the at least one cold fluid flows.
- 10 22. The apparatus according to Claim 20 comprising means for sending gaseous nitrogen from the at least one cryogenic air distillation plant to the additional heat exchanger.
- 15 23. The apparatus according to Claim 15 comprising means for sending pressurised oxygen from the cryogenic air distillation plant to at least one of a GTL plant, a methanol plant and a DME plant fed by natural gas.
- 20 24. The apparatus according to Claim 15 wherein all of the refrigeration required to liquefy the natural gas is derived from a single cryogenic air distillation plant, the columns of the plant, the main heat exchanger and the further heat exchanger being situated within a single cold box.
- 25 25. The apparatus according to Claim 15 wherein part of the refrigeration required to liquefy the natural gas is derived from at least two cryogenic air distillation plants, each comprising a main heat exchanger and distillation columns, said main heat exchanger and distillation columns being within the cold box, the part of the refrigeration required to liquefy the natural gas being produced by vaporisation of at least one liquid stream, enriched in oxygen, nitrogen or argon, produced by one of the distillation columns, and the natural gas liquefies by heat exchange in a further heat exchanger by heat exchange with a cold fluid removed from each cryogenic air distillation plant.
- 30 26. The apparatus according to Claim 15 comprising means for precooling the natural gas prior to undergoing indirect heat exchange with said cold fluid.

27. The apparatus according to Claim 26 wherein said means for precooling comprises a heat exchanger and means for sending propane to the heat exchanger.
- 5 28. An integrated process for the separation of air by cryogenic distillation and liquefaction of natural gas (LNG) which comprises the steps of:
- i. providing at least part of the refrigeration from at least one cryogenic air distillation plant;
 - 10 ii. liquefying the natural gas by indirect heat exchange in a heat exchanger with a cold fluid, and
- wherein said air distillation plant comprises:
- i. a main heat exchanger; and
 - 15 ii. at least one distillation column.
29. The process according to Claim 28, wherein said cold fluid is sent at least partially in liquid form to the heat exchanger.
30. The process according to Claim 28, wherein said cold fluid undergoes at least partial vaporization in the heat exchanger
- 20 31. The process according to Claim 28, wherein said distillation column is a double column, which comprises a thermally linked medium pressure column and a low pressure column.
- 25 32. The process according to Claim 31, wherein air is expanded in a turbine before it is sent to the medium pressure column.
33. The process according to Claim 28, wherein the refrigeration for the liquefaction of the natural gas undergoes an isentropic expansion.
- 30 34. The process according to Claim 28, wherein said process further comprises the steps of:
- iii. cooling the feed air to a temperature suitable for distillation; and

- iv. vaporizing the cold fluid that comprises a liquid stream enriched in at least one component selected from the group consisting of oxygen, nitrogen and argon.

- 5 35. The process according to Claim 28, wherein the main heat exchanger provides all the cooling for the air to be separated in the cryogenic air distillation plant.
- 10 36. The process according to Claim 28, wherein an additional heat exchanger liquefies the natural gas with at least one pre-cooled fluid from the main heat exchanger.
37. The process according to Claim 36, wherein the process of the main heat exchanger comprises the steps of:
- 15 i. flowing cold fluid within a closed circuit;
ii. cooling said fluid; and
iii. warming said fluid by heat exchange with the liquefying vaporizing natural gas.
- 20 38. The process according to Claim 36, wherein said cold fluid comprises at least one component selected from the group consisting of nitrogen, argon, CF₄, HCF₃, methane, ethane, ethylene and propane.
- 25 39. The process according to Claim 34, wherein gaseous nitrogen is sent from the cryogenic air distillation plant to the additional heat exchanger.
40. The process according to Claim 28, wherein the cryogenic air distillation plant produces pressurized oxygen for at least one plant selected from the group consisting of a GTL plant, a methanol plant, and a DME plant.
- 30 41. The process according to Claim 28, wherein a cold box of a single cryogenic air distillation plant provides all of the refrigeration required to liquefy the natural gas, and wherein said plant comprises:
- i. main heat exchanger;

- ii. at least one distillation column; and
- iii. an additional heat exchanger.

5 42. The process according to Claim 28, wherein part of the refrigeration required to liquefy the natural gas is derived from at least two cryogenic air distillation plants, wherein each plant comprises:

- i. main heat exchanger;
- ii. at least one distillation column; and
- iii. additional heat exchanger,

10 wherein said main heat exchanger provides at least part of the refrigeration required to liquefy the natural gas by the vaporization of at least one liquid stream, enriched in oxygen, nitrogen or argon, produced by one of the distillation columns, and

15 wherein said additional heat exchanger provides at least another part of the refrigeration by exchanging heat with a cold fluid removed from each cryogenic air distillation plant, whereby liquefying the natural gas.

20 43. The process according to Claim 28, wherein the natural gas prior to undergoing indirect heat exchange with said cold fluid is at least partially precooled to a temperature below 0°C by indirect heat exchange with at least one fluid not derived from any cryogenic air distillation plant.

44. The process according to Claim 43, wherein said fluid comprises propane.

25 45. An integrated apparatus for the separation of air by cryogenic distillation and liquefaction of natural gas which comprises:

- i. at least one cryogenic air distillation plant that provides part of the refrigeration; and
- ii. a heat exchanger with a cold fluid that liquefies natural gas by indirect heat exchange.

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46. The apparatus according to Claim 45, wherein said heat exchanger further comprises a cold fluid that is at least partially in liquid form.

47. The apparatus according to Claim 45, wherein said heat exchanger further comprises a means for the cold fluid to undergo at least partial vaporization.
- 5 48. The apparatus according to Claim 45, wherein the distillation column is a double column, which comprises a thermally linked medium pressure column and a low pressure column.
- 10 49. The apparatus according to Claim 45, wherein said apparatus further comprises a gas turbine that provides a means to expand air before it is sent to the medium pressure column.
- 15 50. The apparatus according to Claim 45, wherein the apparatus comprises a refrigeration for the liquefaction of the natural gas that will undergo an isentropic expansion.
- 20 51. The apparatus according to Claim 45, wherein
i. the apparatus comprises means for sending the natural gas to be liquefied to the main heat exchanger of the cryogenic air distillation plant; and
ii. the cold fluid is at least one liquid stream, enriched in at least one component selected from the group consisting of oxygen, nitrogen and argon.
- 25 52. The apparatus according to Claim 45, wherein said apparatus provides means for sending all the air to be separated to the main heat exchanger.
- 30 53. The apparatus according to Claim 45, wherein said apparatus further comprises an additional heat exchanger which receives the natural gas to be liquefied and at least one pre-cooled fluid from the main heat exchanger.
54. The apparatus according to Claim 53, wherein said main and additional heat exchangers contain a closed circuit that permits at least one cold fluid to flow.

55. The apparatus according to Claim 53, wherein said apparatus provides a means for sending gaseous nitrogen from at least one cryogenic air distillation plant to the additional heat exchanger.
- 5 56. The apparatus according to Claim 45, wherein said apparatus provides a means for sending pressurized oxygen from the cryogenic air distillation plant to at least one plant selected from the group consisting of a GTL plant, a methanol plant and a DME plant.
- 10 57. The apparatus according to Claim 45, wherein the single cryogenic air distillation plant provides the means for all of the refrigeration required to liquefy the natural gas.
- 15 58. The apparatus according to Claim 45, wherein at least two cryogenic air distillation plants provide part of the refrigeration required to liquefy the natural gas.
- 20 59. The apparatus according to Claim 58, wherein each said distillation plant comprises a cold box that provides all the refrigeration required to liquefy the natural gas, wherein said plant further comprises:
- i. main heat exchanger;
 - ii. at least one distillation column;
 - iii. an additional heat exchanger; and
- 25 wherein said main heat exchanger provides at least part of the refrigeration required to liquefy the natural gas by vaporization of at least one liquid stream, enriched in at least one component selected from the group consisting of oxygen, nitrogen and argon, produced by one of the distillation columns, and
- 30 wherein the additional heat exchanger provides another part of the refrigeration by exchanging heat with a cold fluid removed from each cryogenic air distillation plant, whereby liquefying the natural gas.

60. The apparatus according to Claim 45, wherein the apparatus provides the means for natural gas to be pre-cooled prior to undergoing indirect heat exchange with said cold fluid.
- 5 61. The apparatus according to Claim 45, wherein said heat exchanger provides a means for precooling and sending propane to the heat exchanger.
62. An apparatus that enables an integrated process for the separation of air by cryogenic distillation and liquefaction of natural gas in which at least part of the refrigeration required to liquefy the natural gas comprises at least one
10 cryogenic air distillation plant which further comprises:
- i. a main heat exchanger;
 - ii. at least one distillation column, and
- wherein the natural gas liquefies by indirect heat exchange in a heat
15 exchanger with a cold fluid, and
- wherein the cold fluid sent to the heat exchanger is at least partially in liquid form and undergoes at least a partial vaporization in the heat exchanger.